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(54) Measuring system for partial discharges

(57) The present invention relates to a method and a device for detecting partial discharges in cables and accessories, comprising the following steps of: interrupting the metal earth shield of the cable; connecting both sides of the interrupted sheath to a measuring instrument; arranging a connection between both sides of the interrupted sheath which is at least suitable for transferring the signals with the mains frequency; and displaying the signal, wherein only signal components with frequencies greater than 0.5 MHz are displayed.

As a result of these steps, the interference associated with the first mentioned frequency range is avoided. It is noted here that the signal/noise ratio of the frequency range applied according to the invention is more favourable.

In order to properly be able to examine the quality of a partial discharge, it is important to relate it to the voltage of the cable in which the partial discharge takes place. The present invention provides a method wherein prior to display the signal is combined with a signal representing the mains voltage.

It is especially attractive when the signal representing the mains voltage is generated in contact-free manner, for example in capacitive manner.

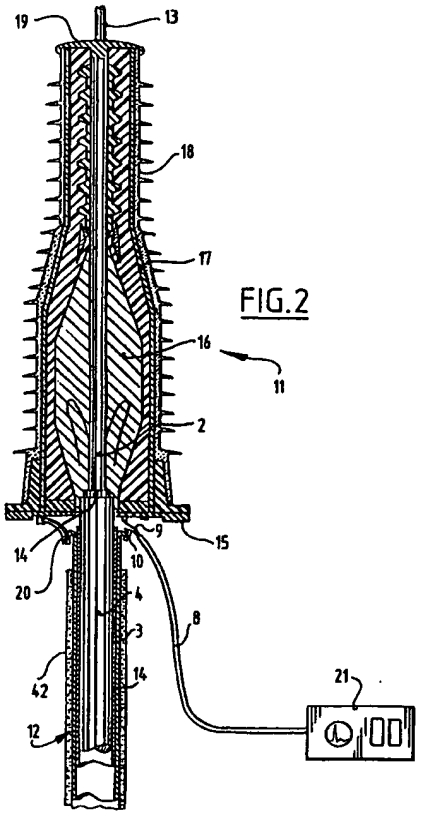

FIG.2

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Description

The present invention relates to a method and a device for measuring partial discharges in cables and fittings.

Partial discharges are discharges which occur in the dielectric located between the inner conductor and the earth shield of a high-voltage cable, wherein complete breakdown does not take place.

The occurrence of such partial discharges causes deterioration of the quality of a cable. Partial discharges are also often the initiator of complete discharges (breakdown).

Partial discharges occur inter alia in cables provided with a dielectric manufactured from plastic. With the increasing use of such cables it is important to have available a measuring method with which such partial discharges can be detected, also in the case of already installed cables.

Known from the Netherlands patent application 9201944 is a method and a device for detecting partial discharges which makes use of a measuring coil or measuring clip.

This method is however only applicable in cables provided with an earth shield, wherein a conductor incorporated in the earth shield extends helically.

This is certainly not the case with all cables. Large numbers of cables are thus provided with a non-woven, for instance solid, earth shield, wherein this method is not applicable. The present invention relates to a method and device applicable with such cables. In order to be able to determine the occurrence of partial discharges in the case of such a solid metal shield it is necessary to interrupt the metal earth shield.

In order to then not disrupt the good operation of the cable it is necessary or, as the case may be, desirable to short-circuit the metal earth shield on both sides of the interruption in a manner such that the intended measurement is not affected.

By displaying the resulting voltage over the interruption, the quality of the partial discharge can be determined. Understood for instance by displaying is making an image on the screen of an oscilloscope, making a print-out by means of an oscillograph, or possible storing of an image in a memory in digital form. Examination of an image can provide information relating to the seriousness and the nature of the partial discharge.

A method for determining the quality of partial discharges in the insulation of cables is thus generally known comprising the following steps of: interrupting the metal earth shield of the cable; connecting both sides of the interrupted sheath to a measuring instrument; arranging a connection between both sides of the interrupted sheath which is at least suitable for transferring signals with the mains frequency; and displaying the signal.

It will be apparent that the magnitude of the voltages occurring over the interruption is very small, so that very sensitive measuring equipment must be used to display the relevant voltage. It is pointed out that according to the prior art the frequency range extending between 100 Hz and about 0.5 MHz is known. The voltage phenomena associated with such a partial discharge are in any case greatest in the relevant frequency range, so that the signal/noise ratio is the most attractive at that location. Attention is drawn to the fact that many interference signals are however present in the relevant frequency range which originate for instance from broad-casting transmitters, so that such measurements are often disrupted by these interference signals.

The object of the present invention is to avoid the above stated problems.

This object is achieved in that only signal components with frequencies greater than 0.5 MHz are displayed.

As a result of these steps, the interference associated with the first mentioned frequency range is avoided. It is noted here that the signal/noise ratio of the frequency range applied according to the invention is more favourable.

Instead of a cut-off frequency of 0.5 MHz it is possible to select other cut-off frequencies, for instance 1 MHz, 2 MHz, 5 MHz, 10 MHz or intermediate cut-off frequencies.

Another interesting aspect of the said frequency range lies in the fact that although a partial discharge generates phenomena which extend over a frequency range of about 100 Hz to several hundred MHz, the distance over which the relevant signals are transmitted is highly frequency-dependent. Signals with a low frequency generally travel over a great distance, while signals with higher frequencies travel over shorter distances as a result of damping and dispersion.

It is important to know that partial discharges occur in the greatest number of cases in accessories of cables; that is, in cable sleeves, end fittings and the like. This useful circumstance has the advantage that in such accessories an interruption of the sheath of the cable is often already present, or the sheath can be easily interrupted. With this knowledge in mind it is attractive to have available a measuring method which is principally intended for partial discharges situated at a relatively short distance, for instance of a few metres, from the interruption.

The method according to the present invention provides such a method.

The signal for displaying is preferably limited in frequency by short-circuiting the interruption of the earth shield.

It is moreover attractive herein to make use of a device for determining the quality of a partial discharge occurring in the cable comprising: means for deflecting a measuring voltage occurring over an interruption of the earth shield; and an instrument for displaying the measuring voltage, characterized in that the deflecting means are formed by an interruption of the sheath of the cable, wherein both sides of the interruption are con-

nected to the measuring instrument and the interruption of the earth shield is short-circuited by a connection suitable for allowing passage of signals with a frequency smaller than 0.5 MHz.

In order to properly be able to examine the quality of a partial discharge, it is important to relate it to the voltage of the cable in which the partial discharge takes place. The present invention provides a method wherein prior to display the signal is combined with a signal representing the mains voltage.

It is especially attractive when the signal representing the mains voltage is generated in contact-free manner, for example in capacitive manner. This has the advantage that the measuring equipment does not have to be connected to conductors carrying high-voltage, so that the measurement, certainly when an interruption of the sheath of the cable is already present, can be performed without interrupting operation of the cable. It will be apparent that this is a significant advantage. It is attractive to derive the signal representing the mains voltage in capacitive manner by making use of an electrode coupled capacitively to a conductor carrying the mains voltage.

Such a method is applicable for single-phase systems such as occur in power supply systems of rail networks supplied with alternating current.

For use in the much more usual three-phase systems the signal representing the mains voltage is generated by at least two, preferably three, electrodes each of which is coupled capacitively to a conductor carrying the relevant phase voltage.

It is noted here that the use of such a capacitive measuring system is known from the publication "Three-phase voltage measurements with simple open air sensors", 7th International Symposium on High Voltage Engineering, Dresden, 26-30 August 1991.

The present invention will subsequently be elucidated with reference to the annexed drawings, in which:

figure 1 shows a schematic, perspective view of a cable in which a partial discharge is transmitted, wherein the earth shield of this cable is provided with an interruption for detecting the partial discharge;
figure 2 is a sectional view of an end fitting, wherein an interruption of the sheath of the cable is present for detecting the partial discharge;
figure 3 is a schematic view of a capacitive measuring system; and
figure 4 shows a perspective, schematic view of an arrangement for performing the method according to the invention.

Shown in figure 1 is a cable 1 with a coaxial structure, which cable is formed by a central conductor 2 and a sheath conductor 3, between which is arranged a dielectric 4. For protection and insulation, plastic insulation material 42 is present around the sheath conductor 3.

Due to the occurrence of a partial discharge which is indicated by 5, a current travelling in lengthwise direction of the cable will begin to flow in the sheath. Because the cable sheath is provided with an interruption 6, it is possible to measure the voltage caused by the current and occurring over this interruption. Connected for this purpose over the interruption is a measuring cable 8 of which two conductors 9, 10 respectively are connected to both pieces of the sheath 3 located on either side of the interruption 6. In order to arrive at a filtering action according to the invention the interruption 6 in sheath 3 is short-circuited only for signals with low frequencies via the connecting wire 20. The short-circuit otherwise serves to maintain the proper operation of the cable. The high-frequency signals are thus fed to the measuring instrument.

A similar situation is shown in figure 2. Shown herein is an end fitting 11 to which is connected an underground cable 12. Such a situation occurs for instance at the transition between an underground cable and a high-voltage line. The high-voltage line 13 is herein connected to the top of the end fitting 11. The underground cable is provided with a central conductor 2 and a sheath conductor 3, between which is arranged the dielectric 4. Further present are semi-conductor voltage-controlling layers 14 which are however of no significance for the present invention and which are not further discussed. The end fitting 11 rests on a conducting plate 15, while end fitting 11 is formed by an insulating mass 16, a reinforcing housing 17, on the outside of which is arranged a housing 18 also manufactured from insulating material. The construction of the end fitting is not otherwise important and is not discussed further.

In the situation shown in figure 2, the sheath 3 of underground cable 12 is connected to the conducting plate 15 by means of a connecting cable 20 usually made of Litz. There is thus no question here of a complete galvanic interruption but of an interruption which only allows passage of low-frequency signals and which in a three-phase system is formed by the capacitive current of the end fitting or the cable. In other cases the sheath 3 can be connected directly to the conducting plate 15. In that case an interruption of sheath 3 will have to be realized. By not joining the connecting wire directly onto the edges of the interruption but at a distance, for example several centimetres from the interruption, the desired frequency-independent behaviour is even reinforced. The high-frequency signals, that is, with a frequency higher than 0.5 MHz, do not cross over such an interruption. It is thus possible to connect the measuring wire 8 over this interruption by means of the cores 9 and 10. The measurement signal is hereby supplied to the measuring instrument 21.

As already stated in the introduction, the instrument 21 is formed by a display device which can be formed by an oscilloscope, and an oscillograph with which it is possible to obtain oscillograms of the voltage phenomenon, or by a digital instrument with which the result of the measurement can be stored in digital form and sub-

sequently printed out in processed form and made visible.

In order to achieve the advantage of the invention, as also stated in the preamble, use is made of a connection with a filtering action, for instance the short-circuit connection, with which frequencies lower than 0.5, 1, 2, 5 or 10 MHz are largely suppressed. The displayed image is hereby limited to only the signal components whose frequency is higher than the cut-off frequency and which can only travel a short distance along the cable sheath, but wherein such signals are only to a small extent sensitive to, or, as the case may be, influenced by, noise, broadcasting signals and other interference signals.

In order to enable a good interpretation of the displayed signal it is important that this signal is related to the momentary voltage level in the cable in which the partial discharge occurs. It is thus attractive to combine the measurement signal with the supply voltage.

Use is made for this purpose of the structure shown in figure 3. Shown herein is a three-phase system which is formed by three conductors R, S and T which carry a three-phase voltage system. The three conductors R, S and T are situated above a conductor 22 with earth potential formed for instance by the earth surface, above which three electrodes 23,24 and 25 are disposed in insulated manner.

Due to the capacitive coupling between the electrodes 23,24 and 25 and the voltage-carrying conductors R, S and T it is possible to obtain from the voltages occurring on electrodes 23,24 and 25 images of the voltages prevailing on conductors R, S and T. The precise manner in which this takes place does not form part of the invention and reference is made herefor to the above cited journal article "Three-phase voltage measurements with simple open air sensors". It is noted however that use can be made herein of a so-called matrix circuit for deflecting images of the relevant voltages.

It is remarked here that the configuration shown in figure 3 depicts a normally occurring three-phase system. As a consequence of the symmetry of a three-phase system it is possible to make use of only two electrodes.

It is furthermore possible, for instance in the case of single-phase systems, to make use of a single electrode. Because it is only necessary for interpretation of the measurement signals that a relation is obtained with the phase of the voltages prevailing in the conductors, it is in principle sufficient to make use of the signals coming from the electrodes by combining these signals in linear manner.

Finally, figure 4 shows a schematic view of a measuring arrangement. Arranged herein on a conducting surface 26 are end fittings 27,28 and 29 to each of which is connected an underground cable 30,31 and 32 respectively. To the top side of each of the connections are connected respective high-voltage lines 33,34 and 35. The high-voltage lines are herein suspended from a portal 36 by means of insulators 37. In order to perform the measurement the voltages occurring over the interruptions on the underside of the end fittings 27,28 and 29 are fed by means of three measuring cables 8 to the measuring instrument 21. This means that there is a three-fold measurement here; it is of course equally possible to make use of a single measurement or a double measurement.

In order to supply the voltages prevailing on the lines 33,34 and 35 use is made of three electrodes 23, 24,25 which in this embodiment are each annular and which rest on the conducting surface 26 by means of an insulating stem 38 and insulating connections 39. Each of the electrodes is connected by means of cables 40 to a matrix circuit 41, which matrix circuit calculates the voltage prevailing on the lines 33,34 and 35 from the voltages occurring on the electrodes 23,24,25 and supplies the desired phase voltage to the measuring instrument 21.

The method of combining the measurement signal with the mains voltage is not limited to the method for obtaining the measurement signal described in the present application; it can also be applied in for instance the method according to the Netherlands patent application number 92.01944.

Claims

1. Method for detecting partial discharges in the insulation of cables and accessories comprising the following steps of:

   - interrupting the metal earth shield of the cable;
   - connecting both sides of the interrupted sheath to a measuring instrument;
   - arranging a connection between both sides of the interrupted sheath which is at least suitable for transferring signals with the mains frequency; and
   - displaying the signal,

   characterized in that only signal components with frequencies greater than 0.5 MHz are displayed.

2. Method as claimed in claim 1, **characterized by** adjusting of the interruption such that only signal components with frequencies greater than 1 MHz, 2 MHz, 5 MHz or 10 MHz are displayed.

3. Method as claimed in claim 1 or 2, **characterized in that** the signal for displaying is limited in frequency by short-circuiting the interruption of the earth shield.

4. Method as claimed in claim 3, **characterized in that** the wire forming the short-circuit is connected to the earth shield at a distance from the interruption.

5. Method as claimed in claim 1, 3 or 4, **characterized in that** prior to display the signal is combined with a signal representing the mains voltage.

6. Method as claimed in claim 5, **characterized in that** the signal representing the mains voltage is generated in contact-free manner.

7. Method as claimed in claim 6, **characterized in that** the signal representing the mains voltage is generated in capacitive manner.

8. Method as claimed in claim 7, **characterized in that** the signal representing the mains voltage is generated by at least one electrode coupled capacitively to a conductor carrying the mains voltage.

9. Method as claimed in claim 8 for use with a three-phase system, **characterized in that** the signal representing the mains voltage is generated by at least two electrodes each of which is coupled capacitively to a conductor carrying phase voltage, while use is made of a matrix circuit.

10. Device for detecting and determining the quality of partial discharge occurring in a cable or in a cable accessory, comprising:

- means for deflecting a measuring voltage occurring over an interruption in the cable;
- an instrument for displaying the measuring voltage,

characterized in that the deflecting means are only suitable for passage of signals with a frequency greater than 0.5 MHz.

11. Device as claimed in claim 10, **characterized in that** the deflecting means are formed by an interruption of the sheath of the cable, wherein both sides of the interruption are connected to the measuring instrument and the earth shield is short-circuited by a connection.

12. Device as claimed in claim 10 or 11, **characterized in that** the connection is suitable only for allowing passage of signals with frequencies lower than 1 MHz, 2 MHz, 5 MHz or 10 MHz.

13. Device as claimed in claim 11 or 12, **characterized in that** the wire forming the short-circuit is connected to the earth shield at a distance from the interruption.

14. Device as claimed in claim 10, 11, 12 or 13, **characterized in that** the device is provided with means combining the measurement signal with a signal representing the mains voltage.

15. Device as claimed in claim 14, **characterized by** means for generating a signal representing the mains voltage, wherein these means comprise: at least one electrode coupled capacitively to a conductor carrying the mains voltage.

16. Device as claimed in claim 15 for use with a three-phase system, **characterized by** at least two electrodes each coupled capacitively to a conductor carrying phase voltage and a matrix circuit connected to the electrodes, wherein the output terminal of the matrix circuit is connected to the measuring instrument.

FIG.1

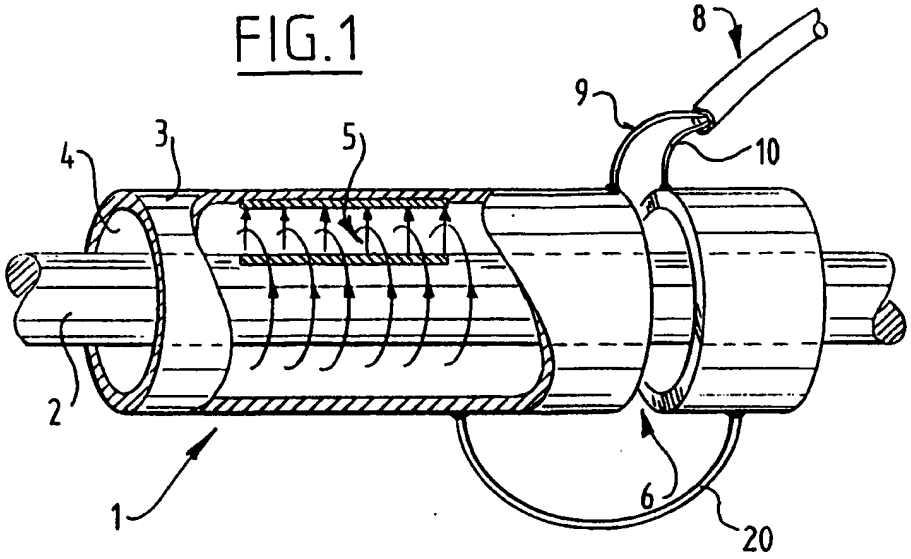
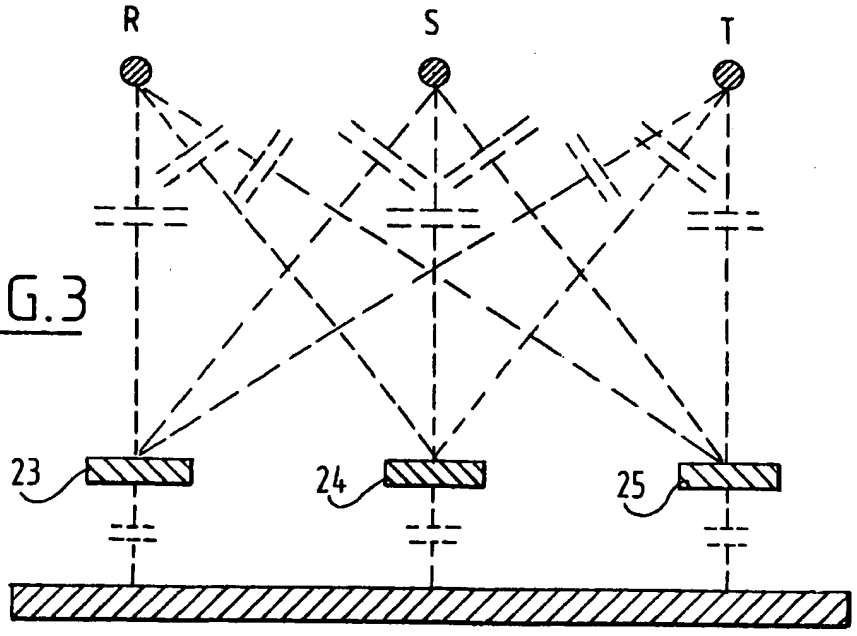


FIG.3



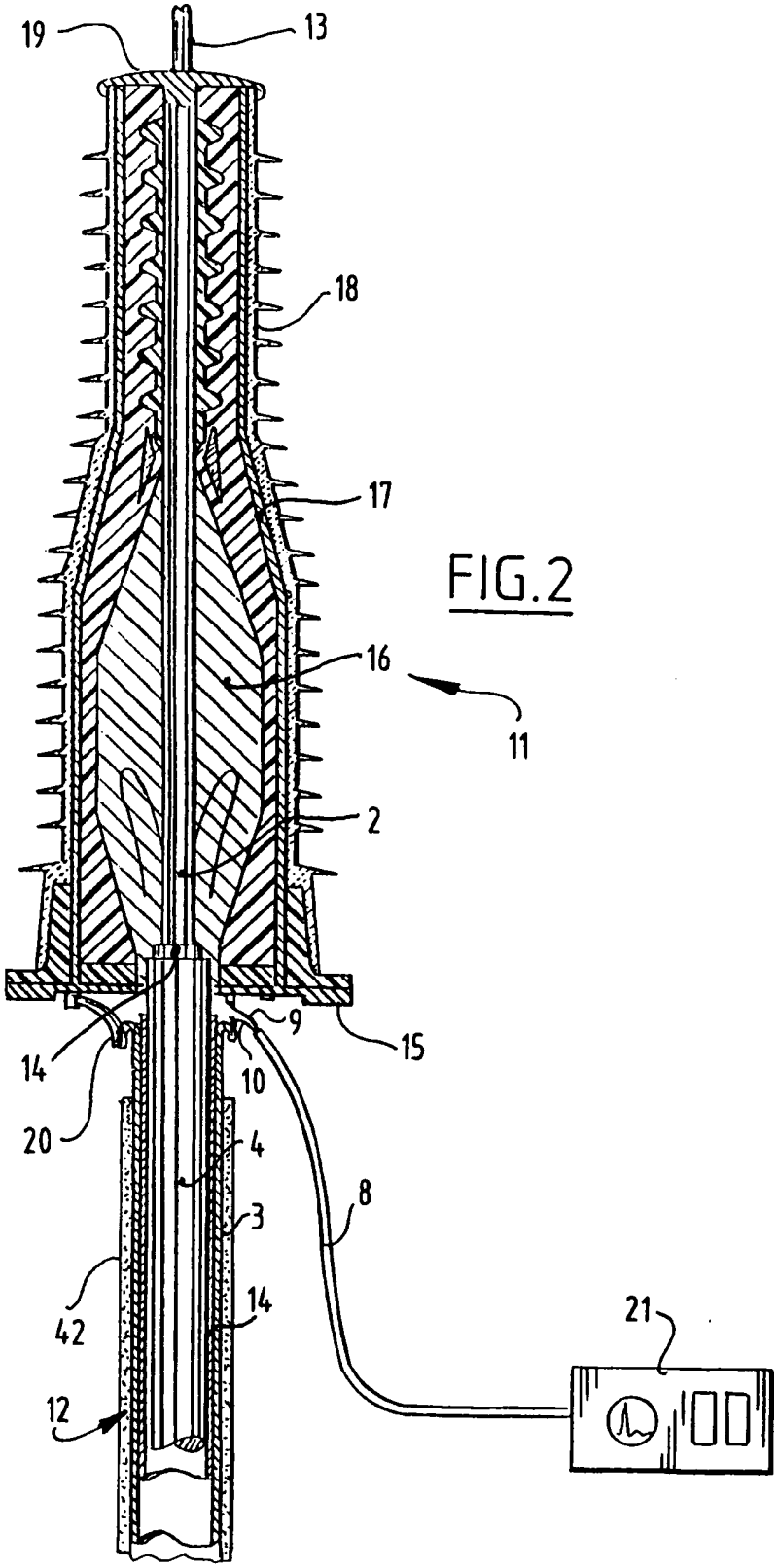
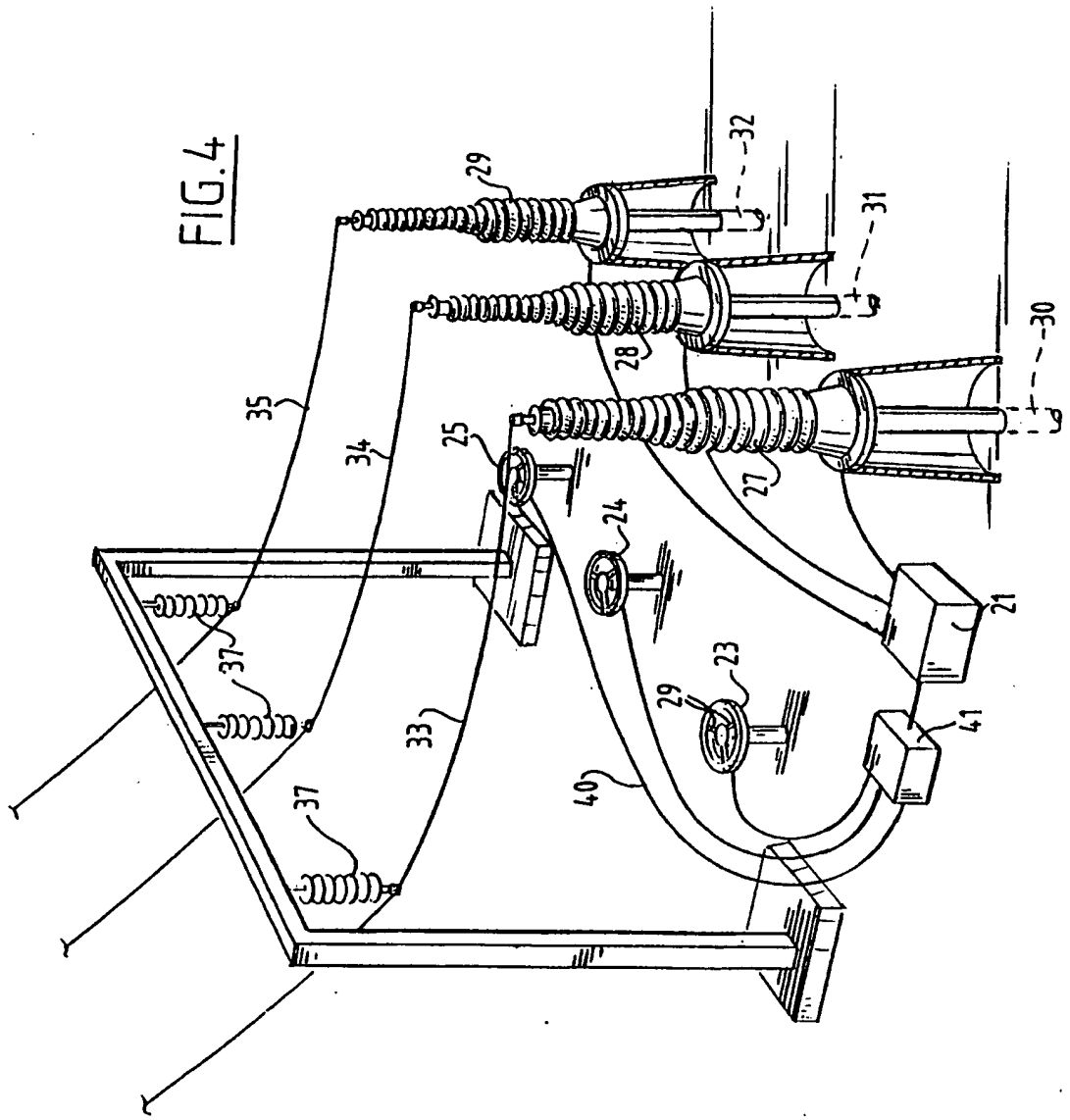


FIG.2

FIG.4



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EUROPEAN SEARCH REPORT

Application Number
EP 95 20 1031

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X	PATENT ABSTRACTS OF JAPAN vol. 17 no. 586 (P-1633) ,26 October 1993 & JP-A-05 172889 (FURUKAWA) 13 July 1993, * abstract *	1-4, 10-13	G01R1/00 G01R31/12 G01R31/08
A	EP-A-0 629 866 (HITACHI) *abstract* * figure 36A *	1	
A,D	WO-A-94 10579 (KEMA) * figure 1 *	1	

TECHNICAL FIELDS SEARCHED (Int.Cl.6)

G01R

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	12 September 1995	Hoornaert, W

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